
بسم الله الرحمن الرحيم

Tanta University

Faculty of Engineering

Electrical Power and Machines Engineering Department

First Year – Second Term

(Electrical Power and Machines Engineering Department)

Course Title

Electrical Circuits (2)

EPM1203 (3+2)

Dr. Said M. Allam

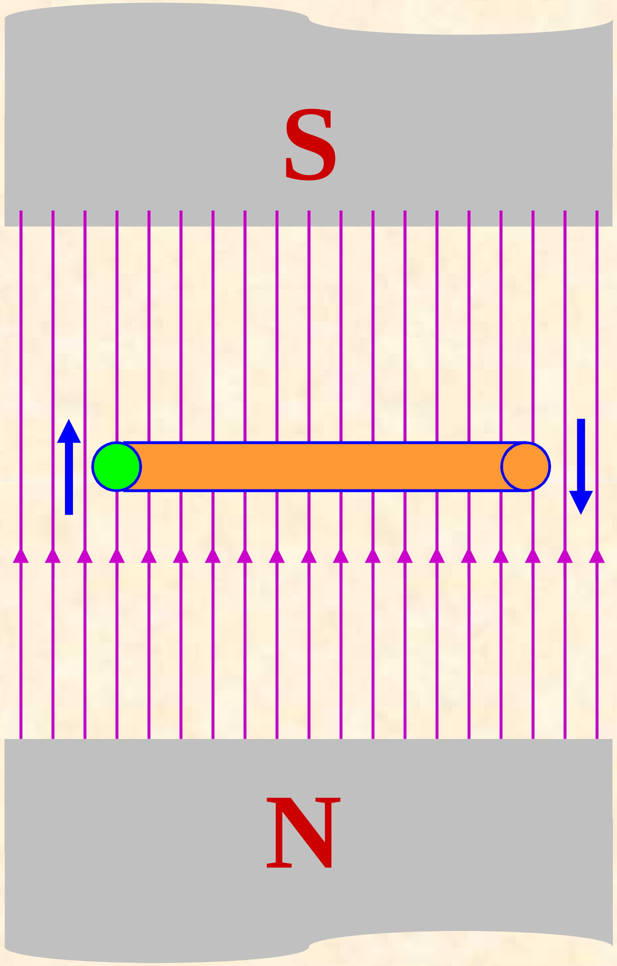
Part 2

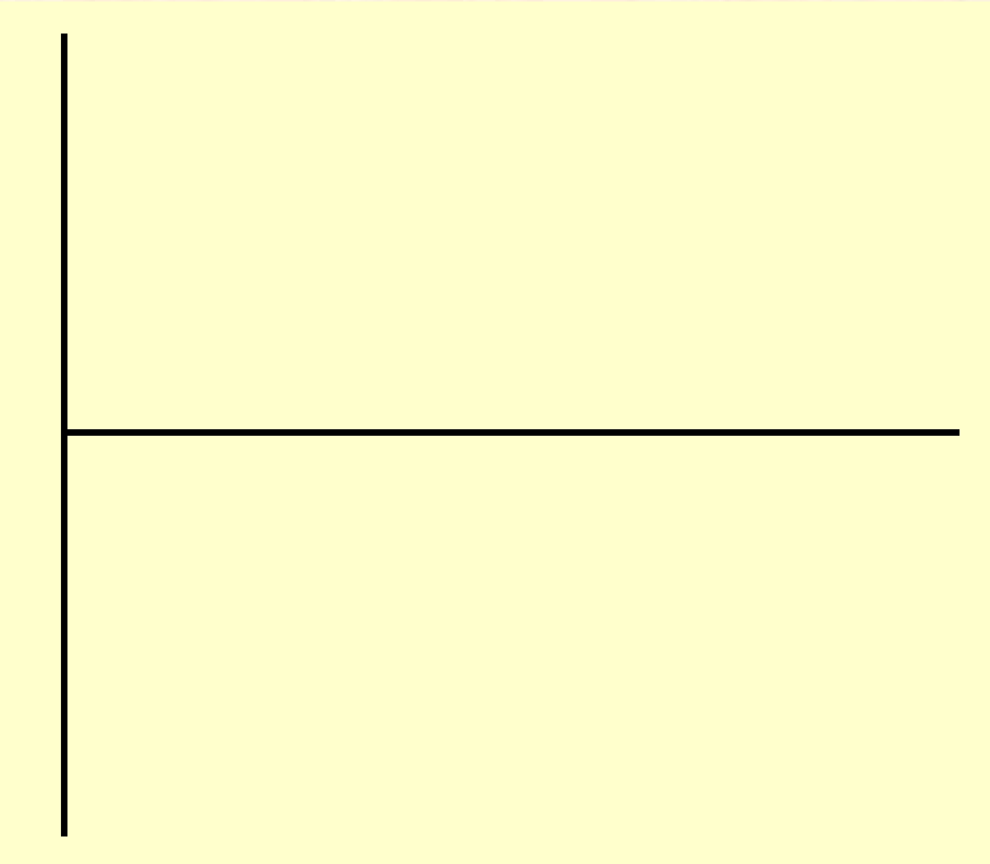
Balanced Three-Phase Circuits

Lecture Outlines

- Generating Single-Phase Voltage
- Generating Three-Phase Voltages
- Importance of Three-Phase System
- Three-Phase Generator
- Basic Three-Phase Circuit
- Y-Y Three-Phase System
- Solved Example on Y-Y System

Generating Single-Phase Voltage

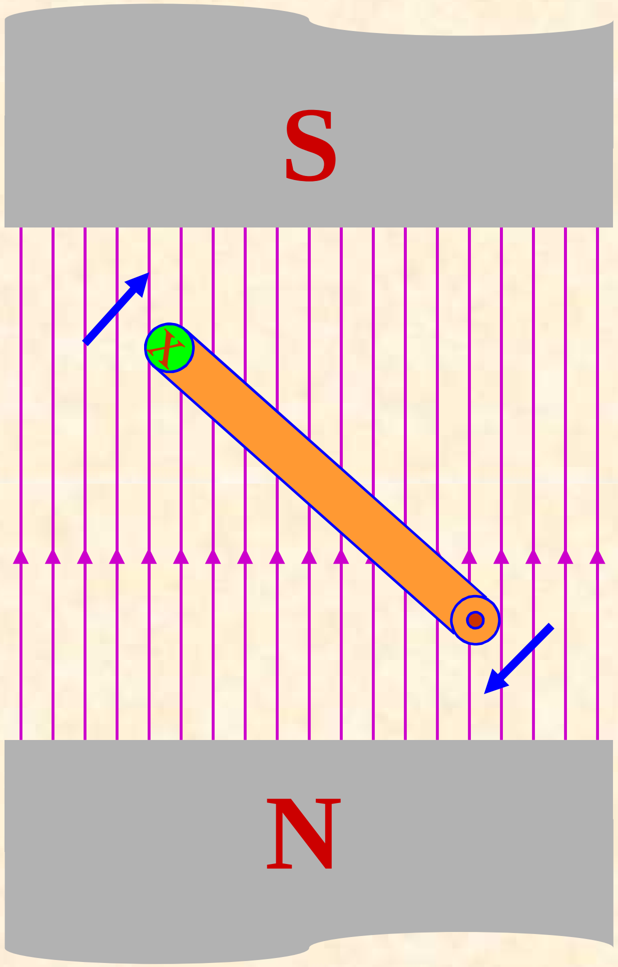


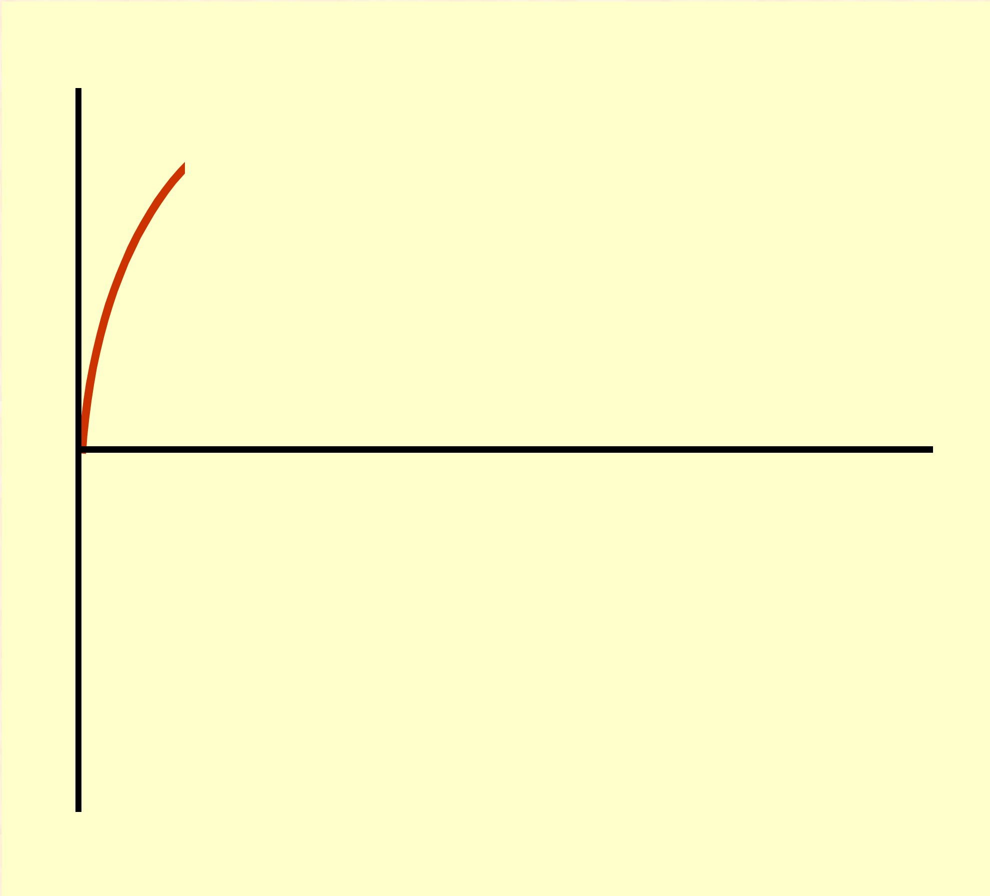


Motion is parallel to the flux

No voltage is induced

Generating Single-Phase Voltage

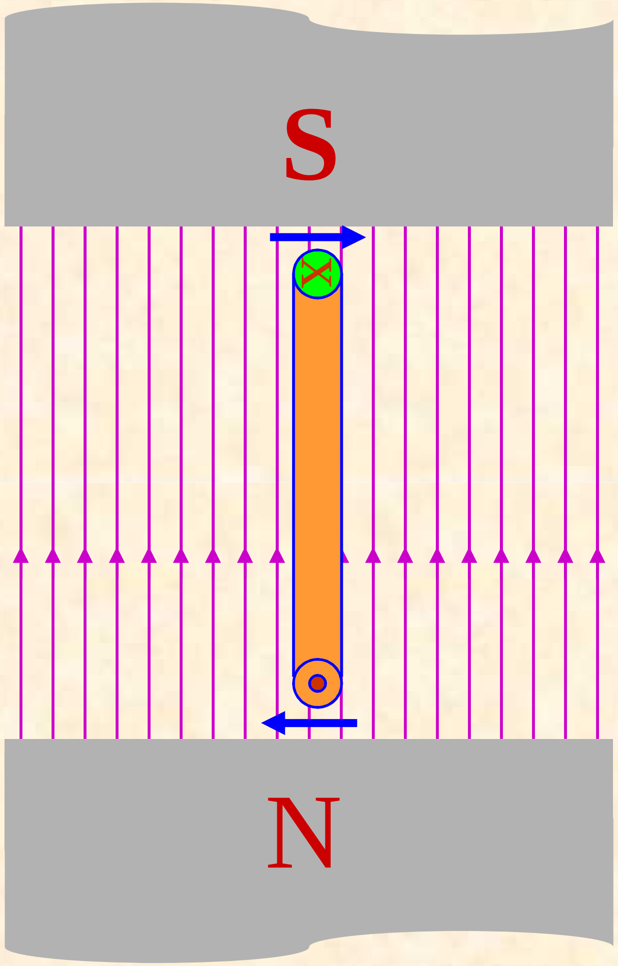


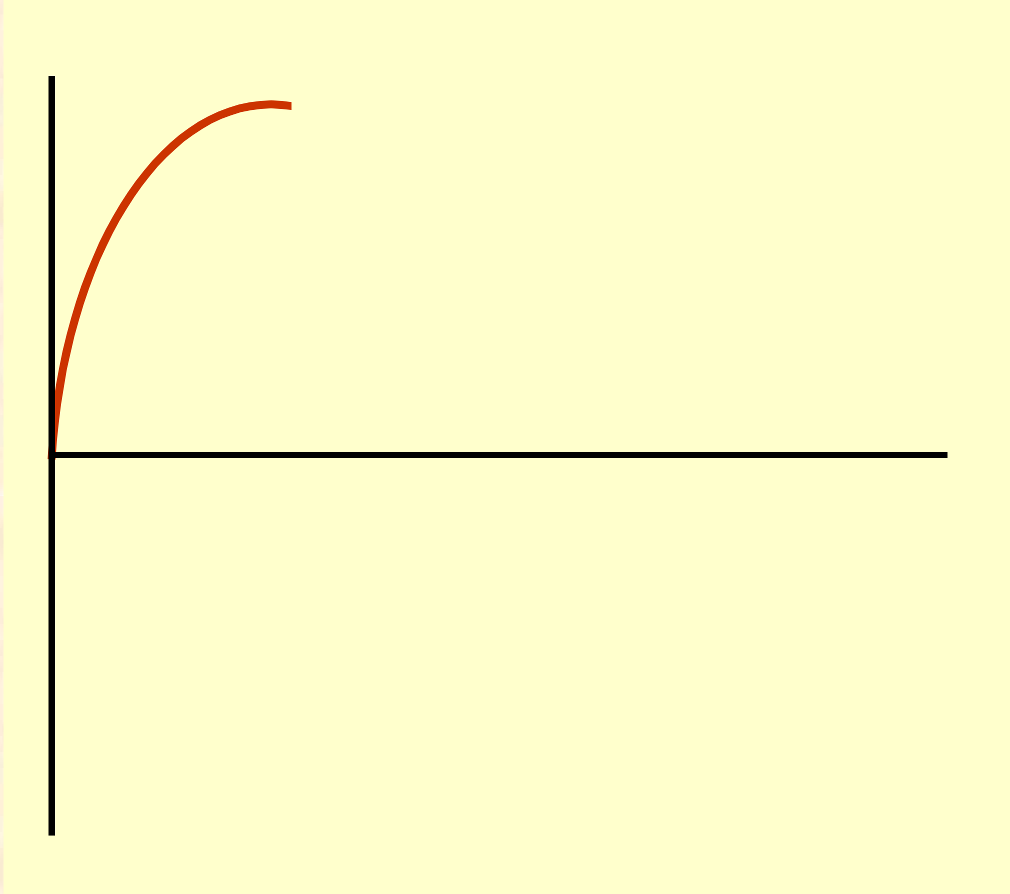


Motion is 45î to flux

Induced voltage is 0.707 of maximum

Generating Single-Phase Voltage

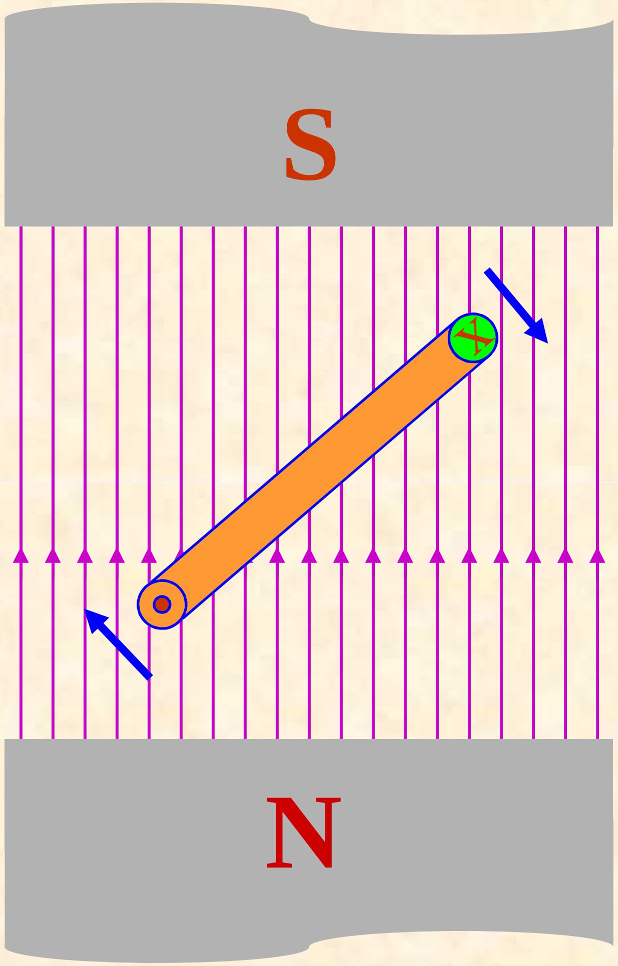


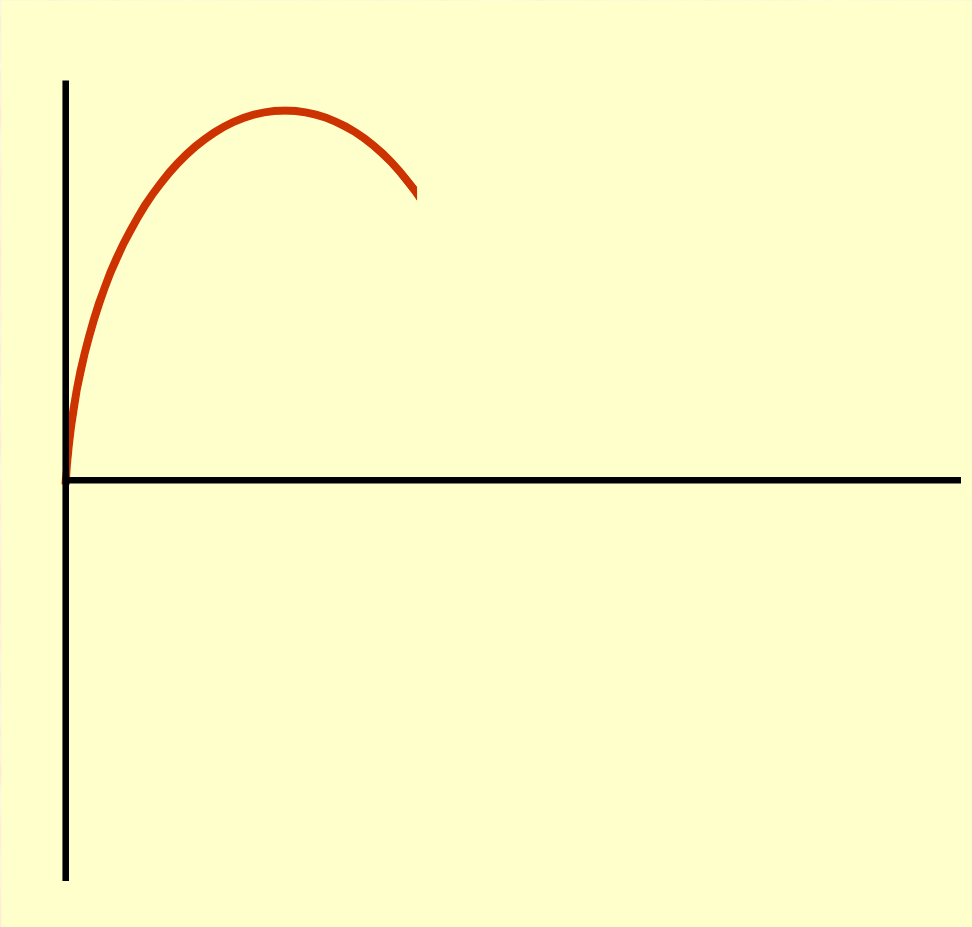


Motion is perpendicular to flux

Induced voltage is maximum

Generating Single-Phase Voltage

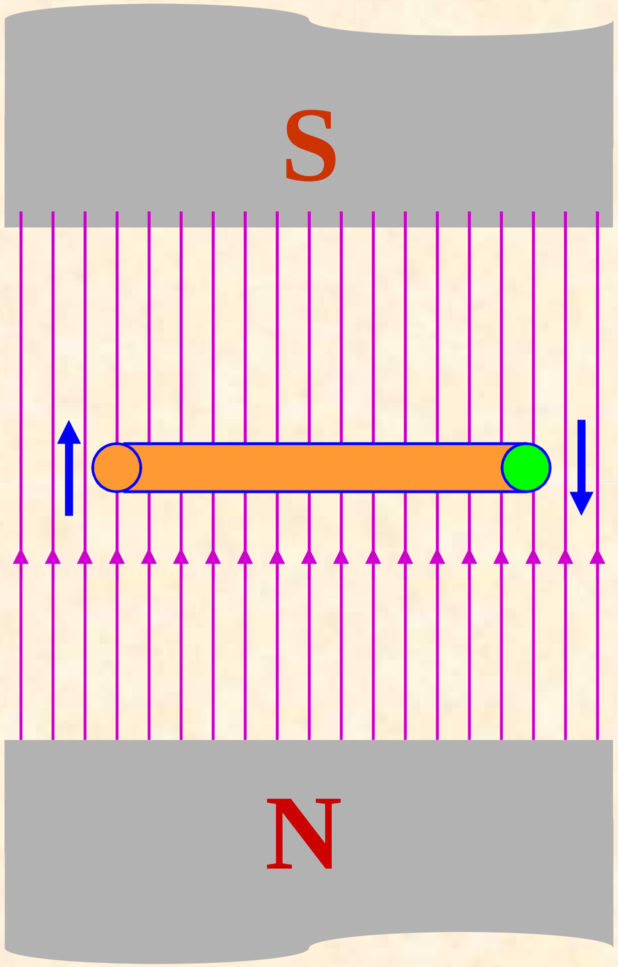


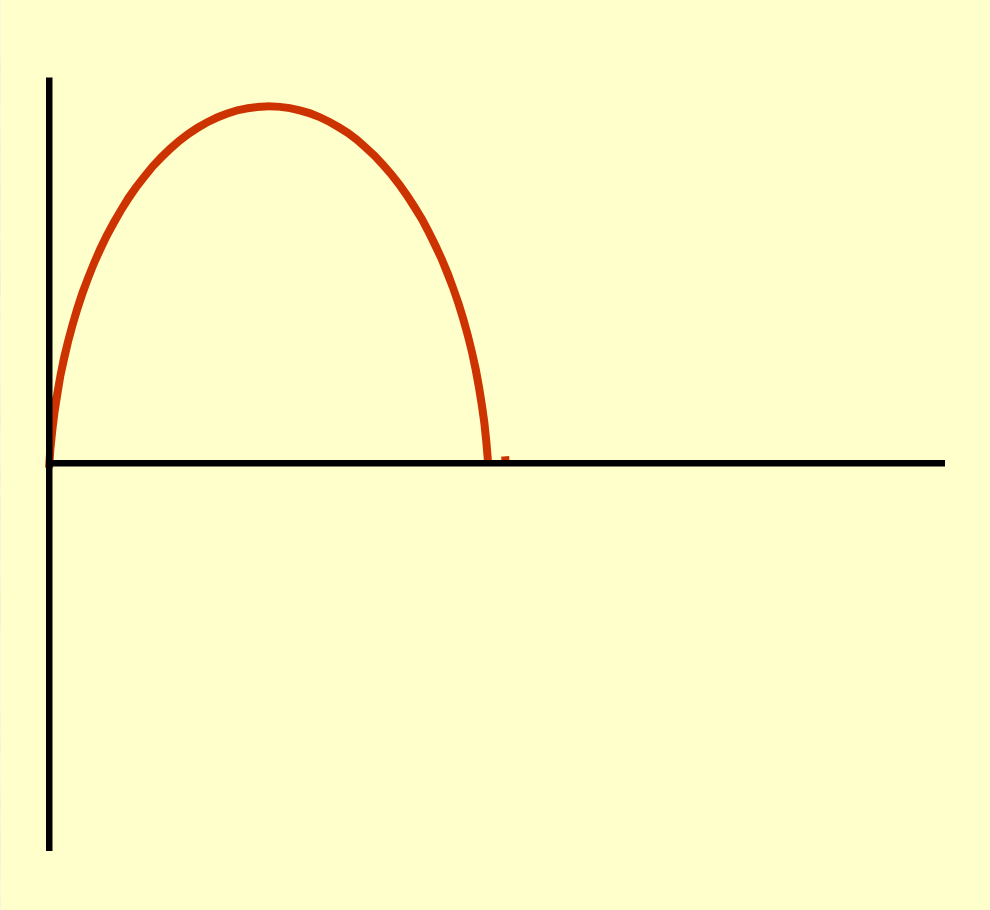


Motion is 45î to flux

Induced voltage is 0.707 of maximum

Generating Single-Phase Voltage

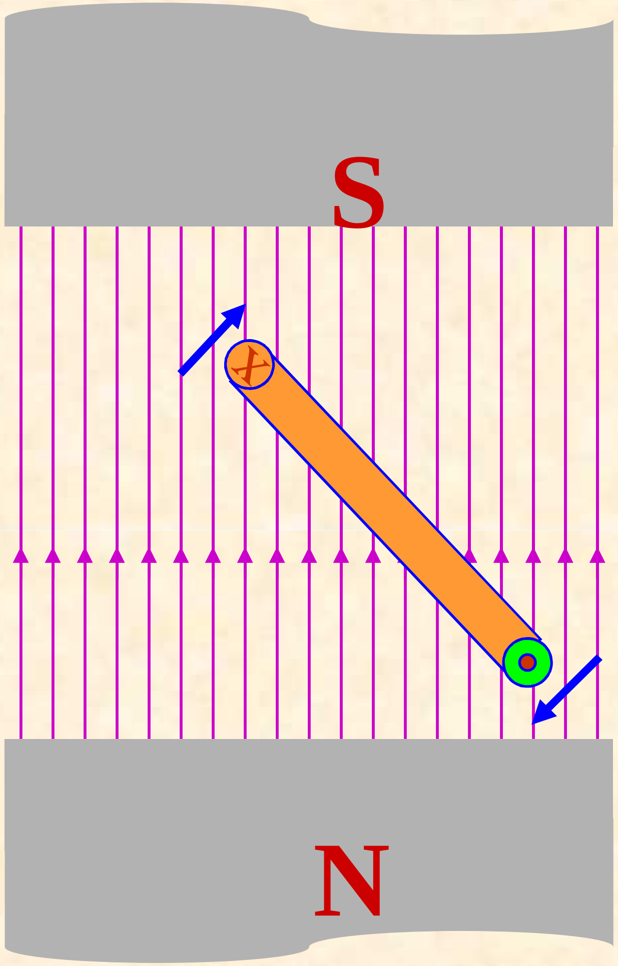


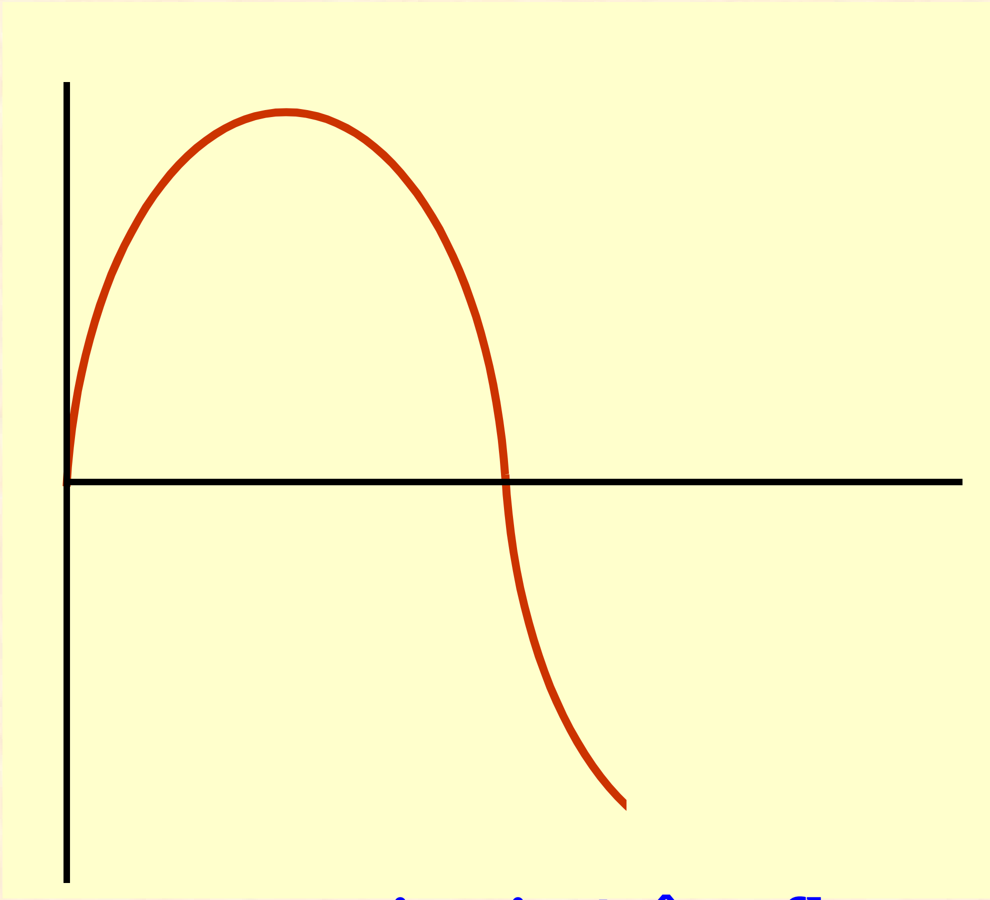


Motion is parallel to flux

No voltage is induced

Generating Single-Phase Voltage



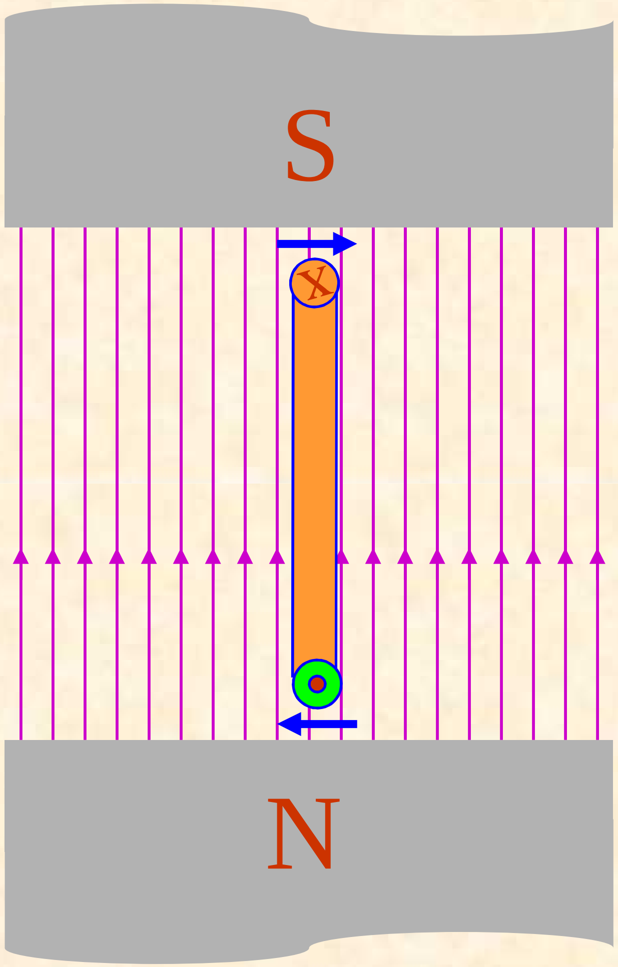


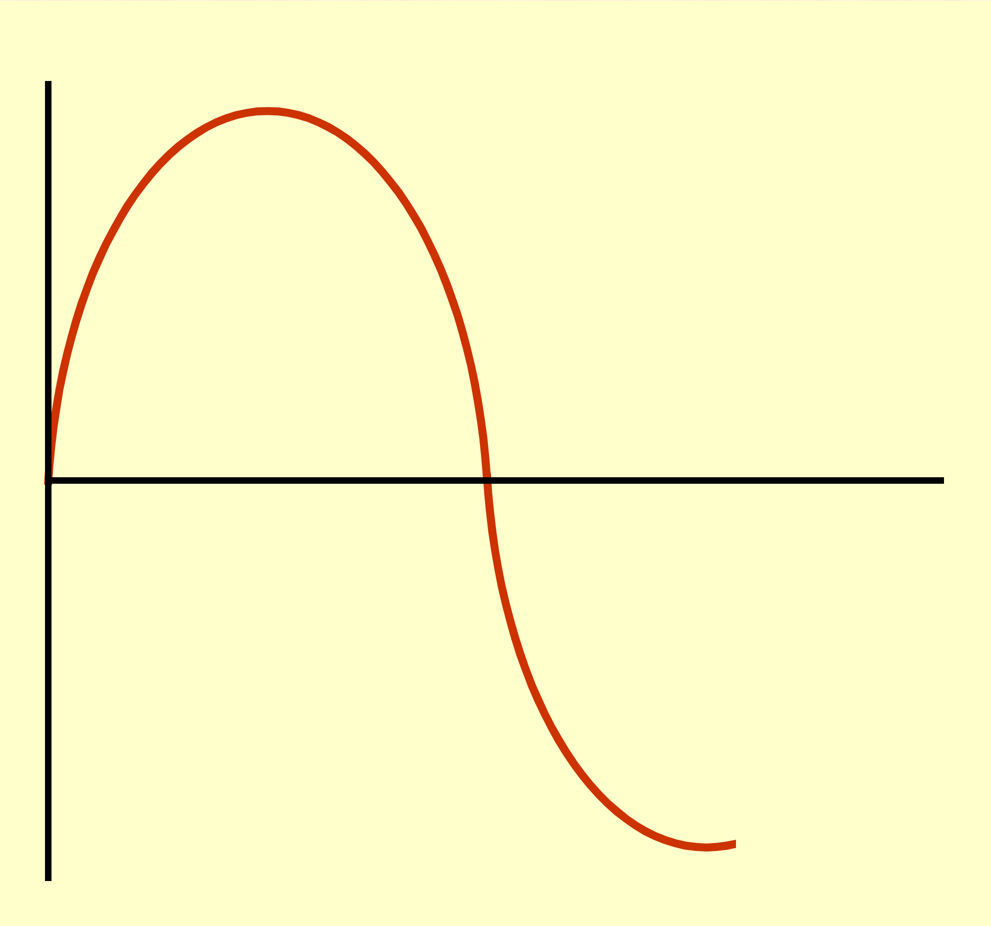
Notice current in the conductor has reversed

Motion is 45î to flux

Induced voltage is 0.707 of maximum

Generating Single-Phase Voltage

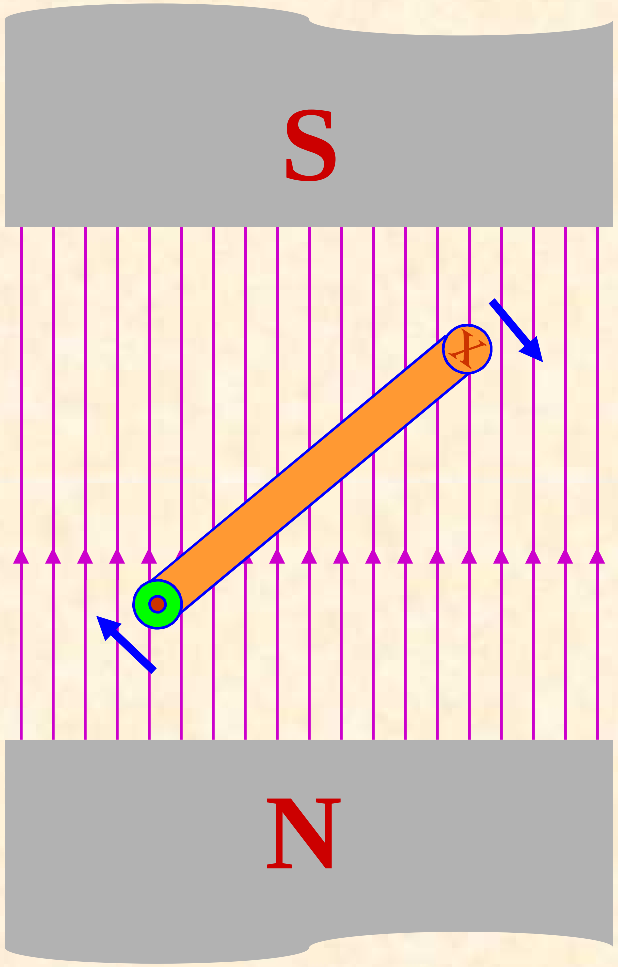


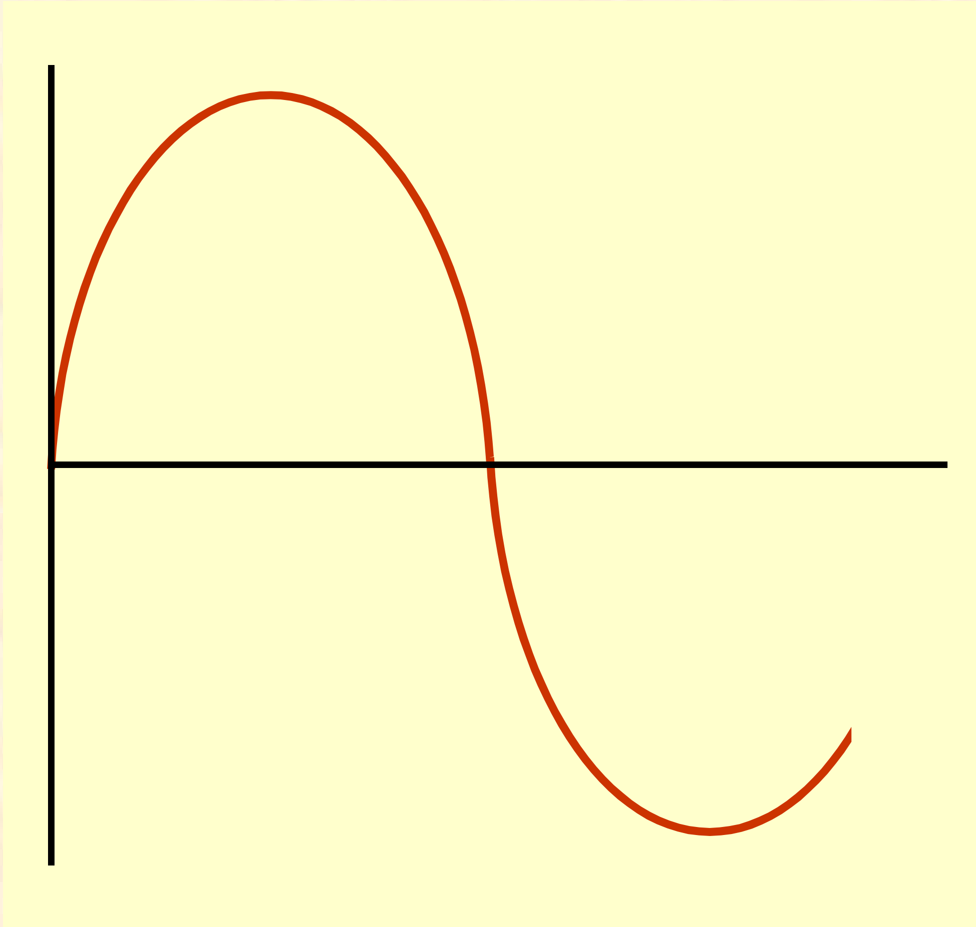


Motion is perpendicular to flux

Induced voltage is maximum

Generating Single-Phase Voltage

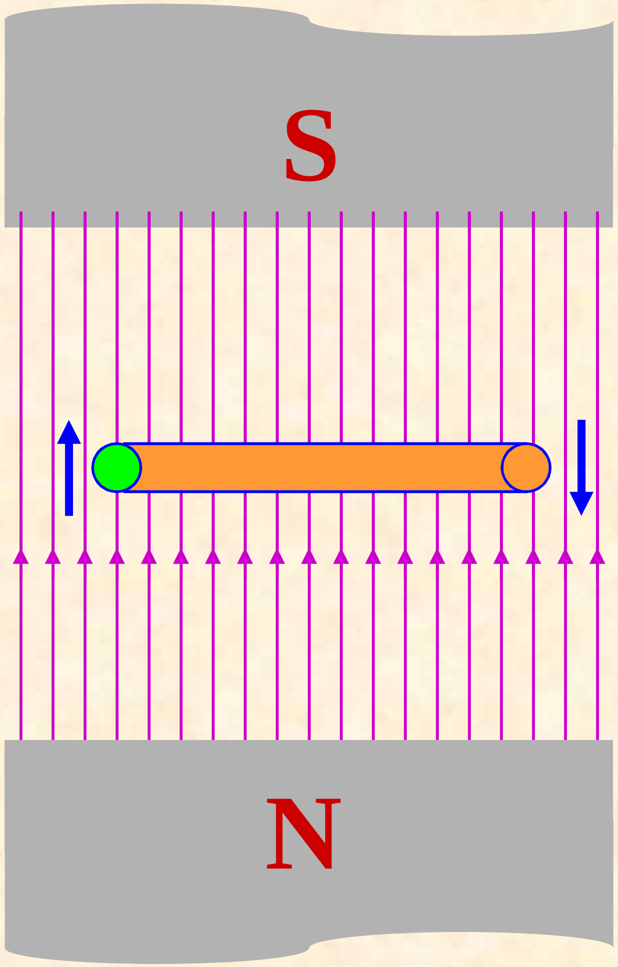


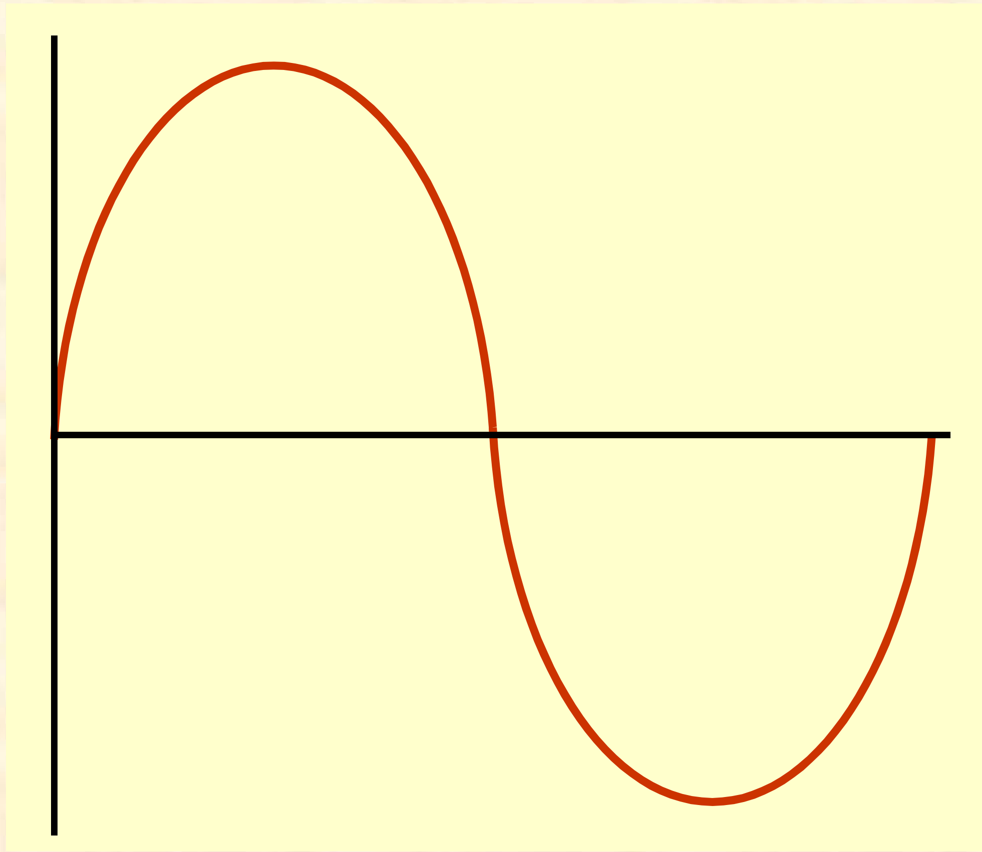


Motion is 45î to flux

Induced voltage is 0.707 of maximum

Generating Single-Phase Voltage



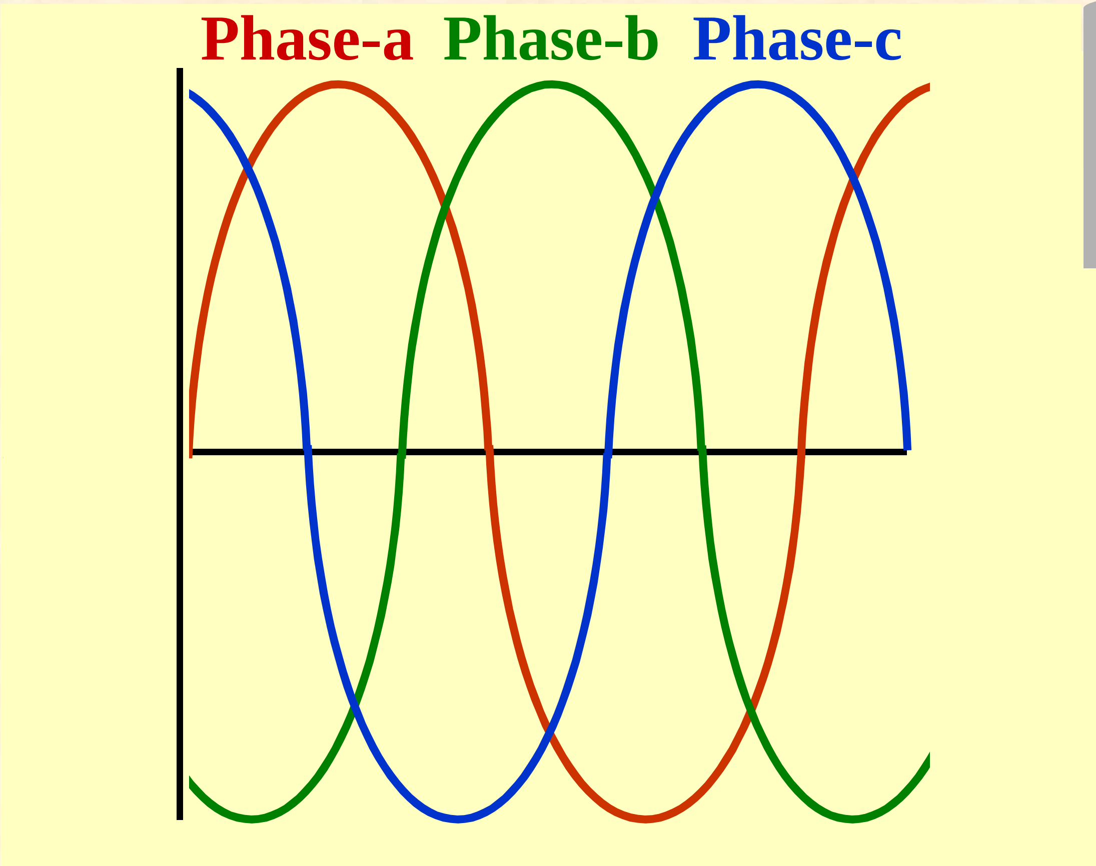


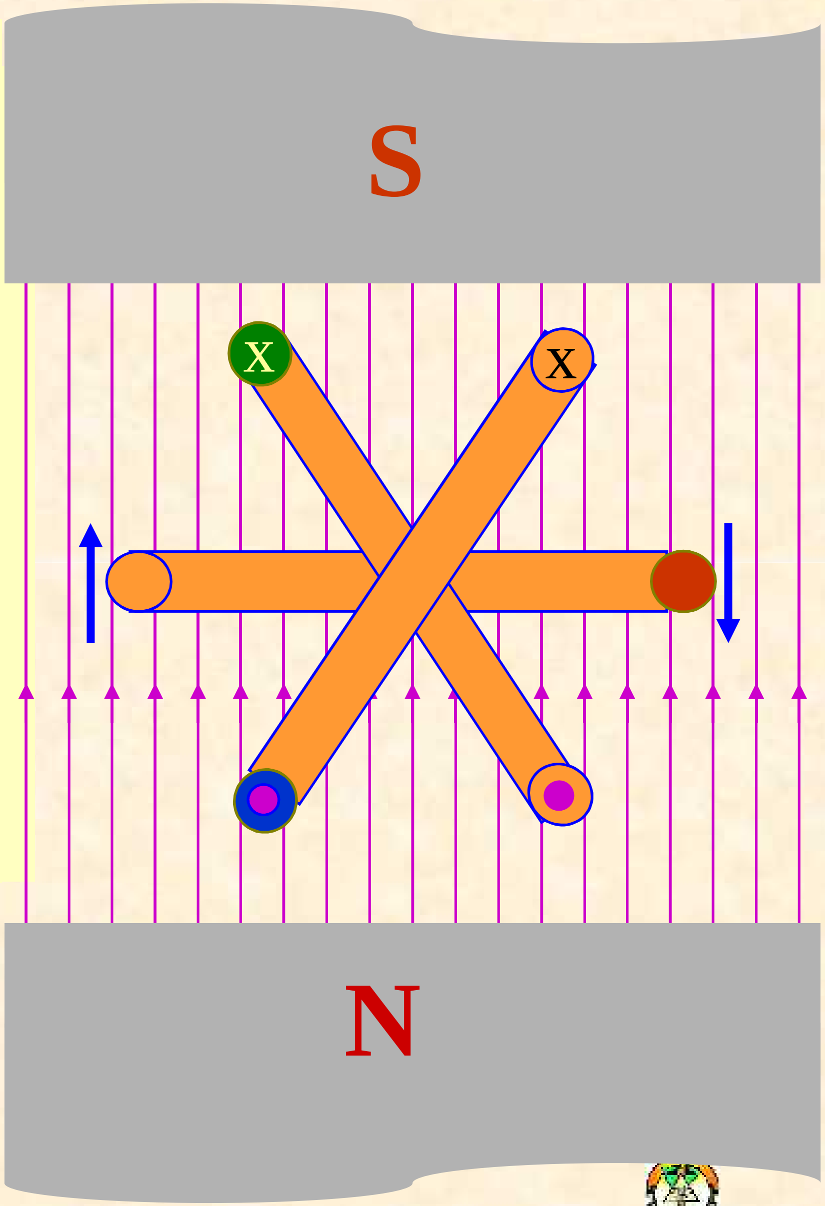
Motion is parallel to flux

No voltage is induced

Ready to produce another cycle

Generating Three-Phase Voltage



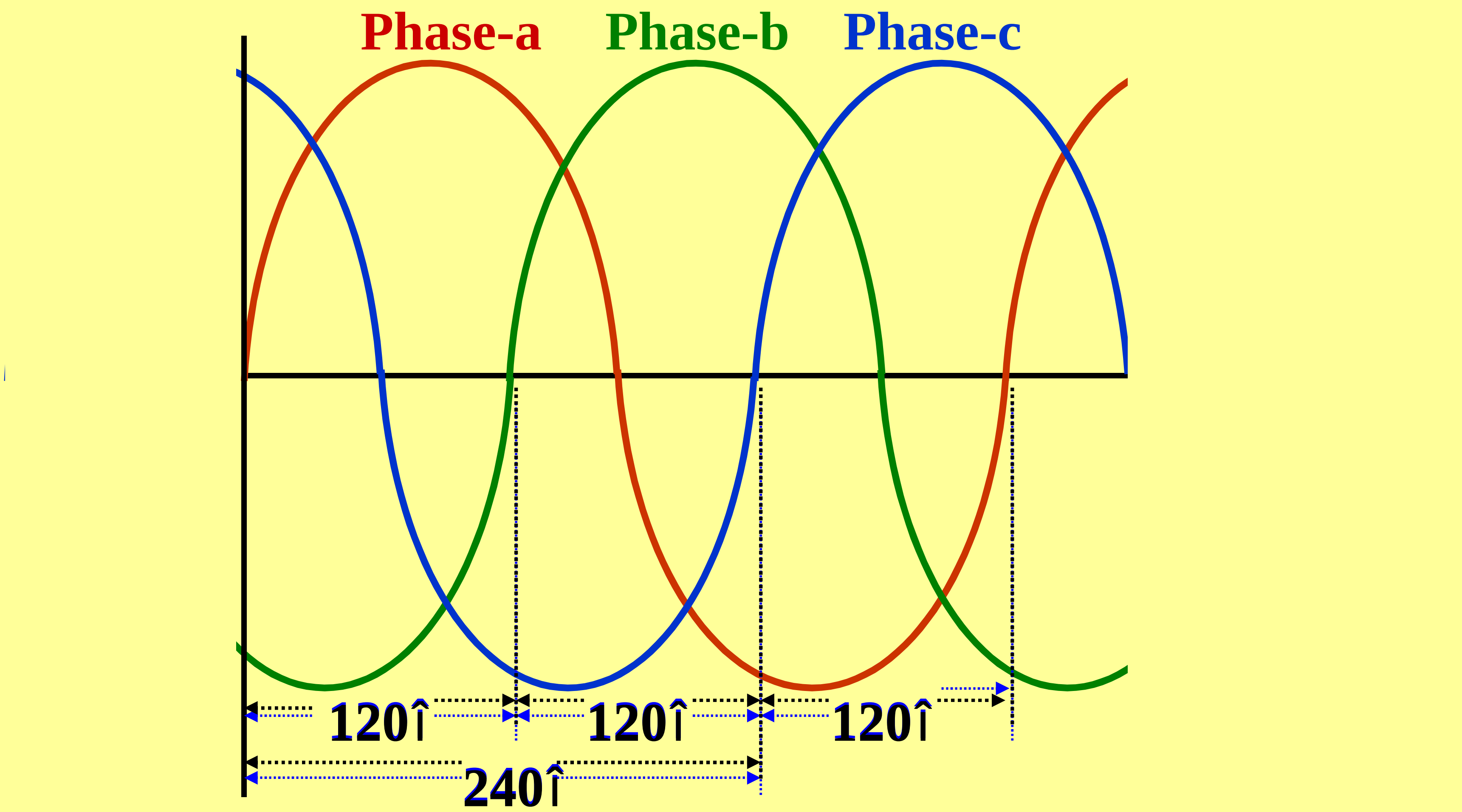


Phase-a is ready to go positive

Phase-b is going more negative

Phase-c is going less positive

Generating Three-Phase Voltage



Phase-b lags phase a by 120î

Phase-b leads phase c by 120î

Phase-c lags phase a by 240î

Phase-a leads phase c by 240î

Importance of Three-Phase System

- All electric power is generated and distributed in three phase

- ✓ **One phase and two phase**, can be taken from three-phase system rather than generated independently
- ✓ The **instantaneous power** in a 3ϕ system can be **constant** (not pulsating)
- ✓ High power motors prefer a **steady torque** especially one created by a rotating magnetic field
- ✓ Three-phase system is **more economical** than the single phase
- ✓ The **amount of wire** required for a three phase system is **less than** required for an equivalent single-phase system

Three-Phase Generator

- The **generator** consists of a rotating magnet (rotor) surrounded by a stationary winding (stator)

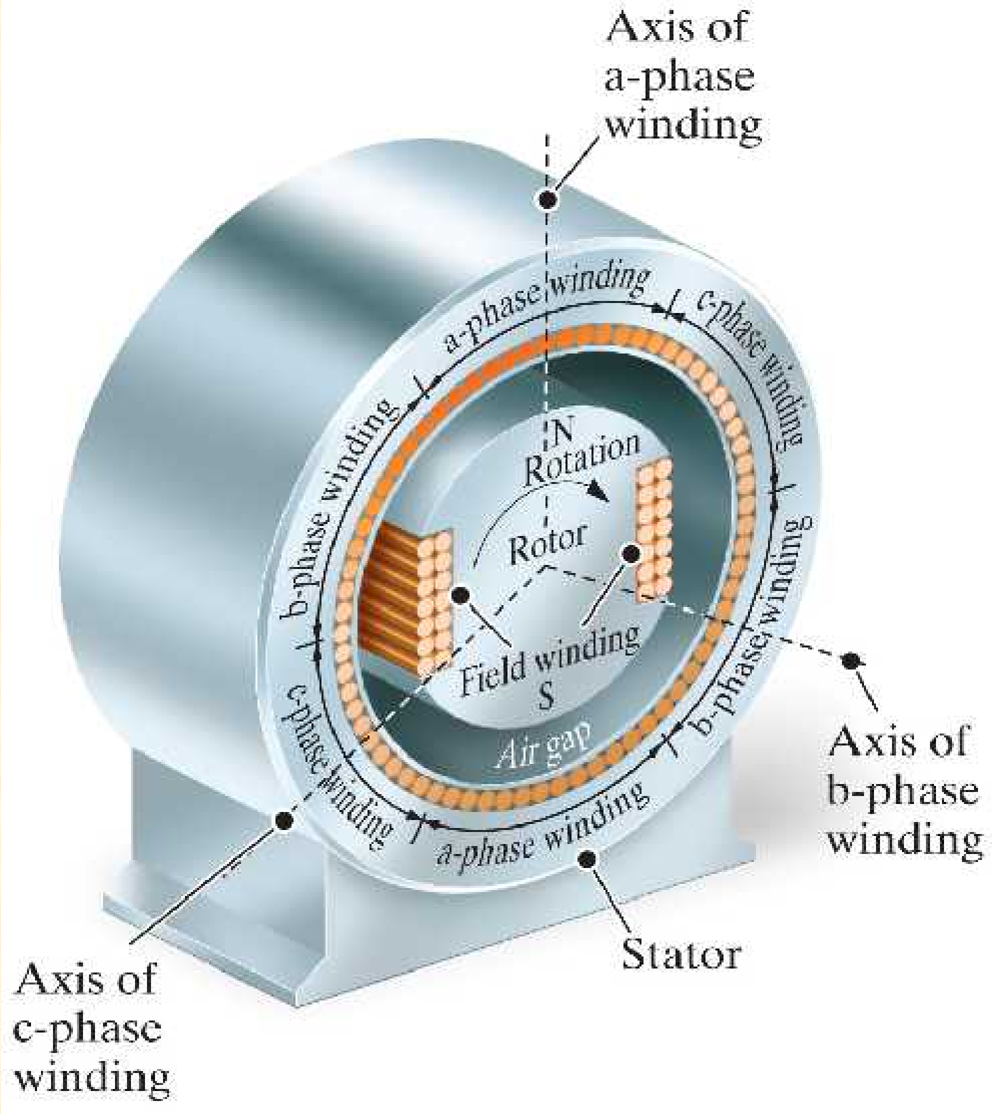
- Three separate windings or coils with terminals a-a', b-b', and c-c' are physically placed 120° apart around the stator

- **As the rotor rotates**, its magnetic field cuts the three coils and induces voltages in the coils

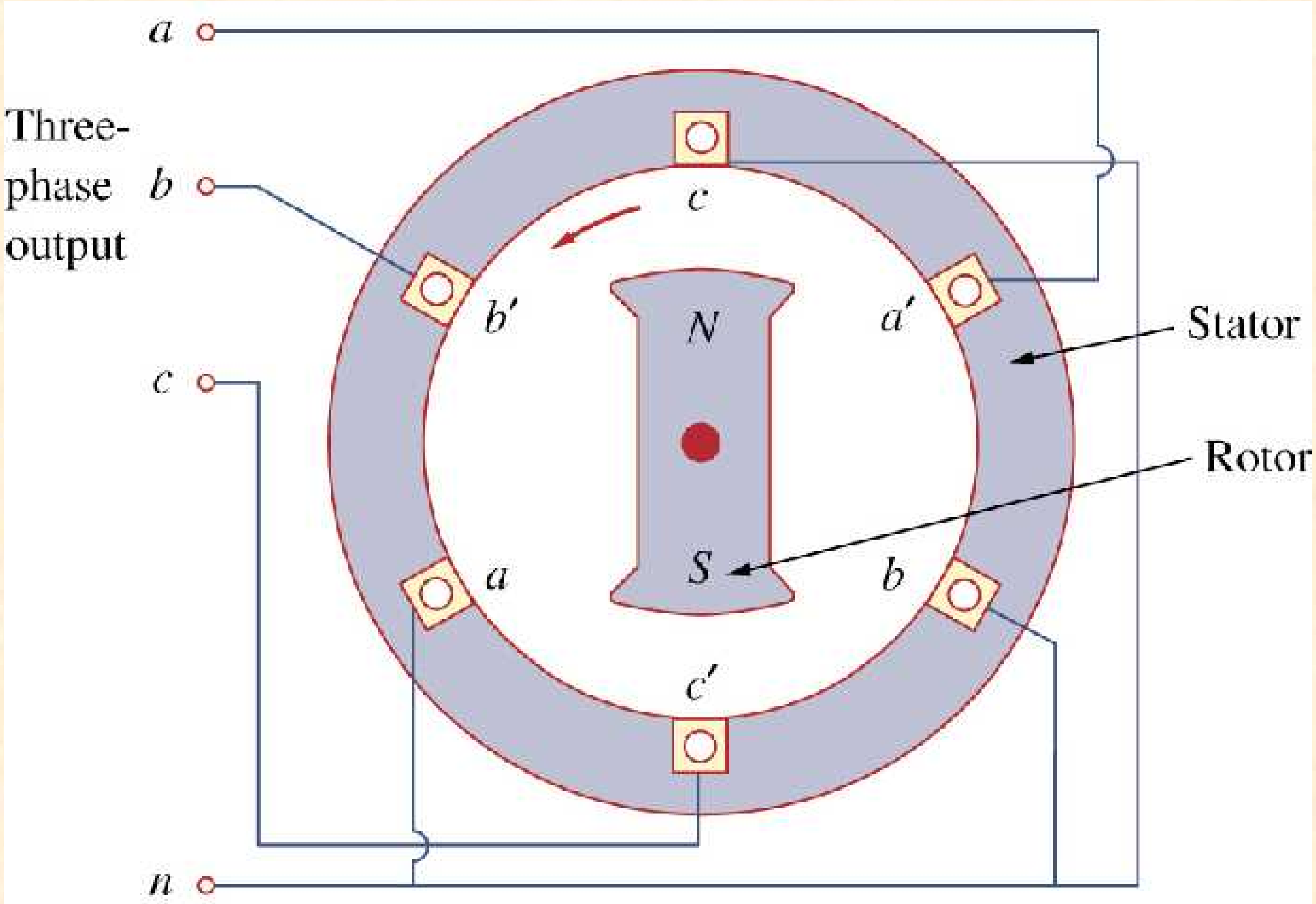
- The **induced voltage** have equal magnitude but out of phase by 120°

Three-Phase Generator

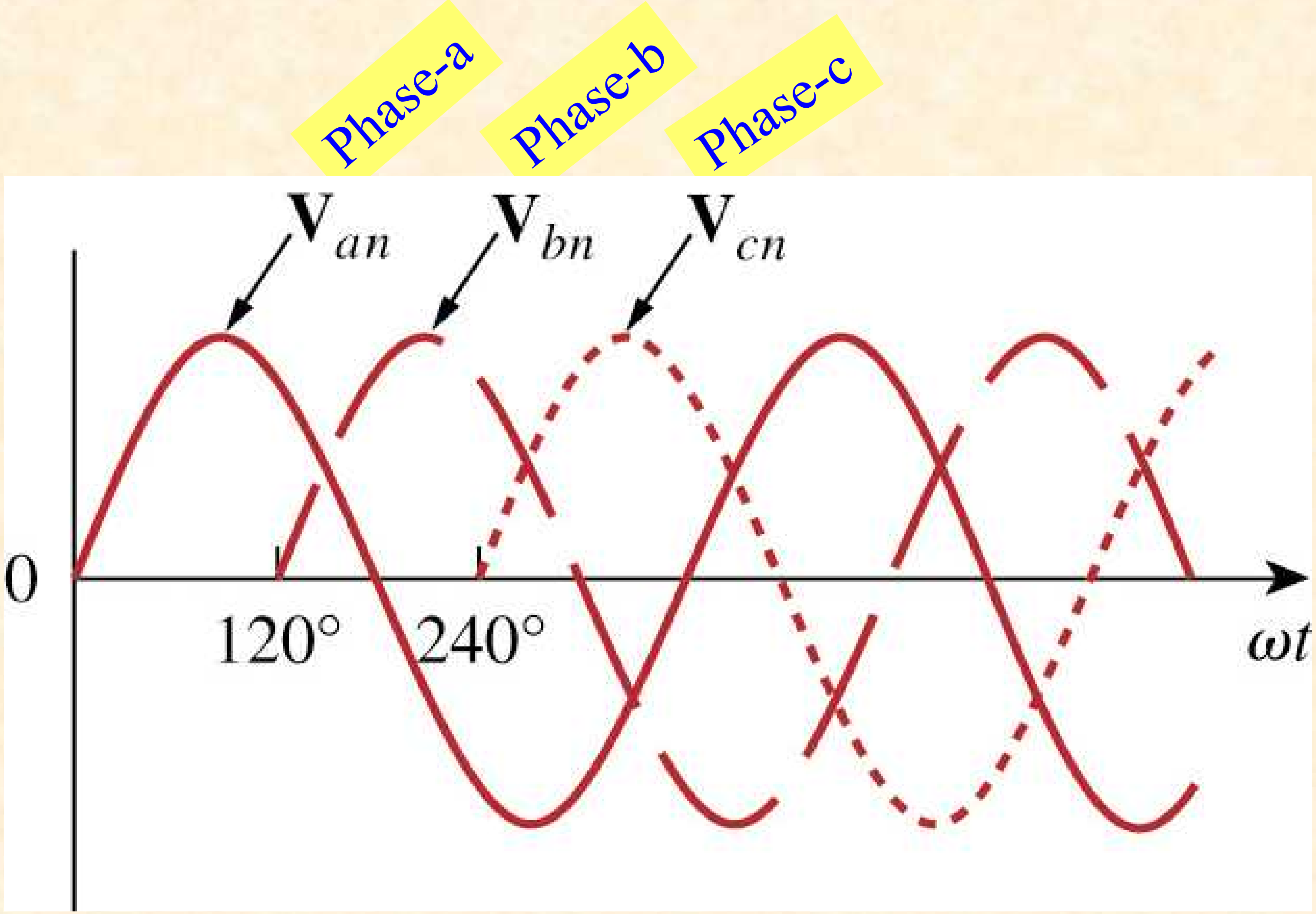
- ✓ 2-pole (North-South) rotor turned by a "prime mover"
- ✓ Sinusoidal voltages are induced in each stator winding



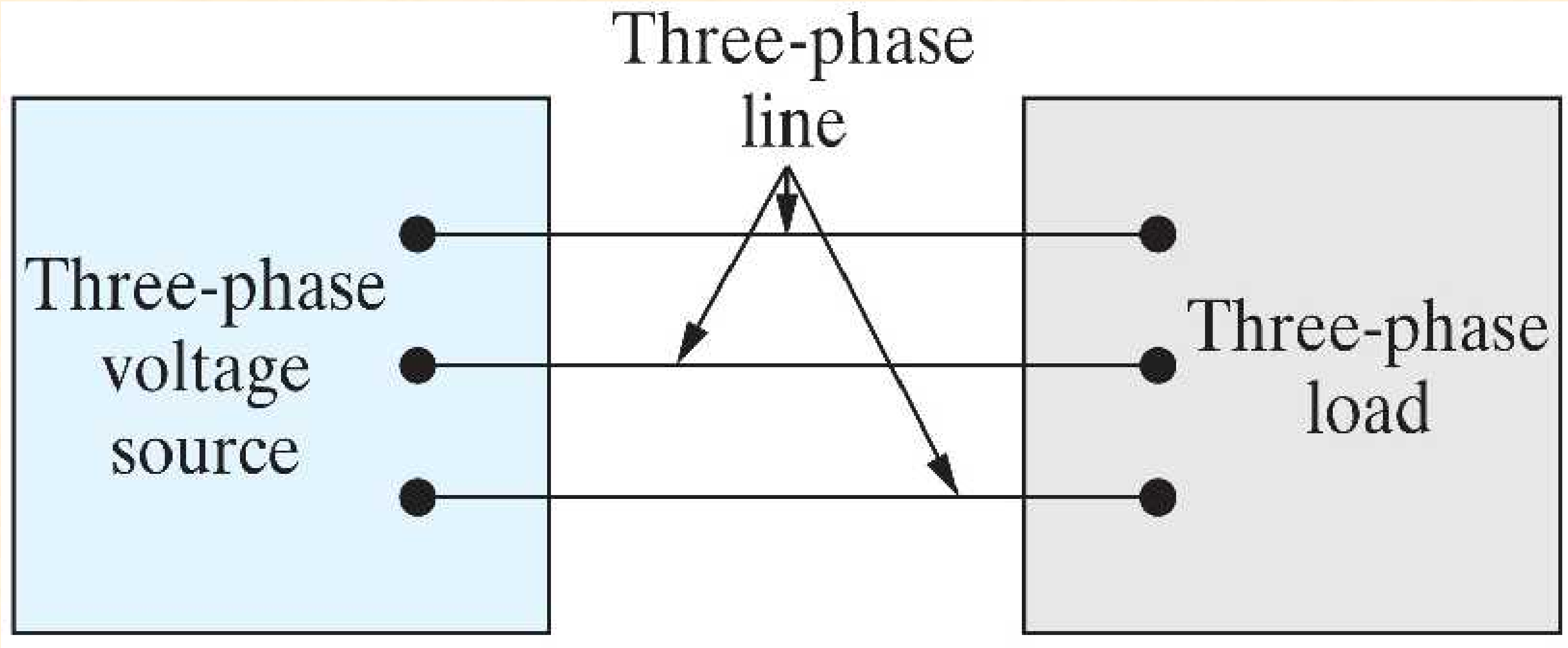
Three-Phase Generator



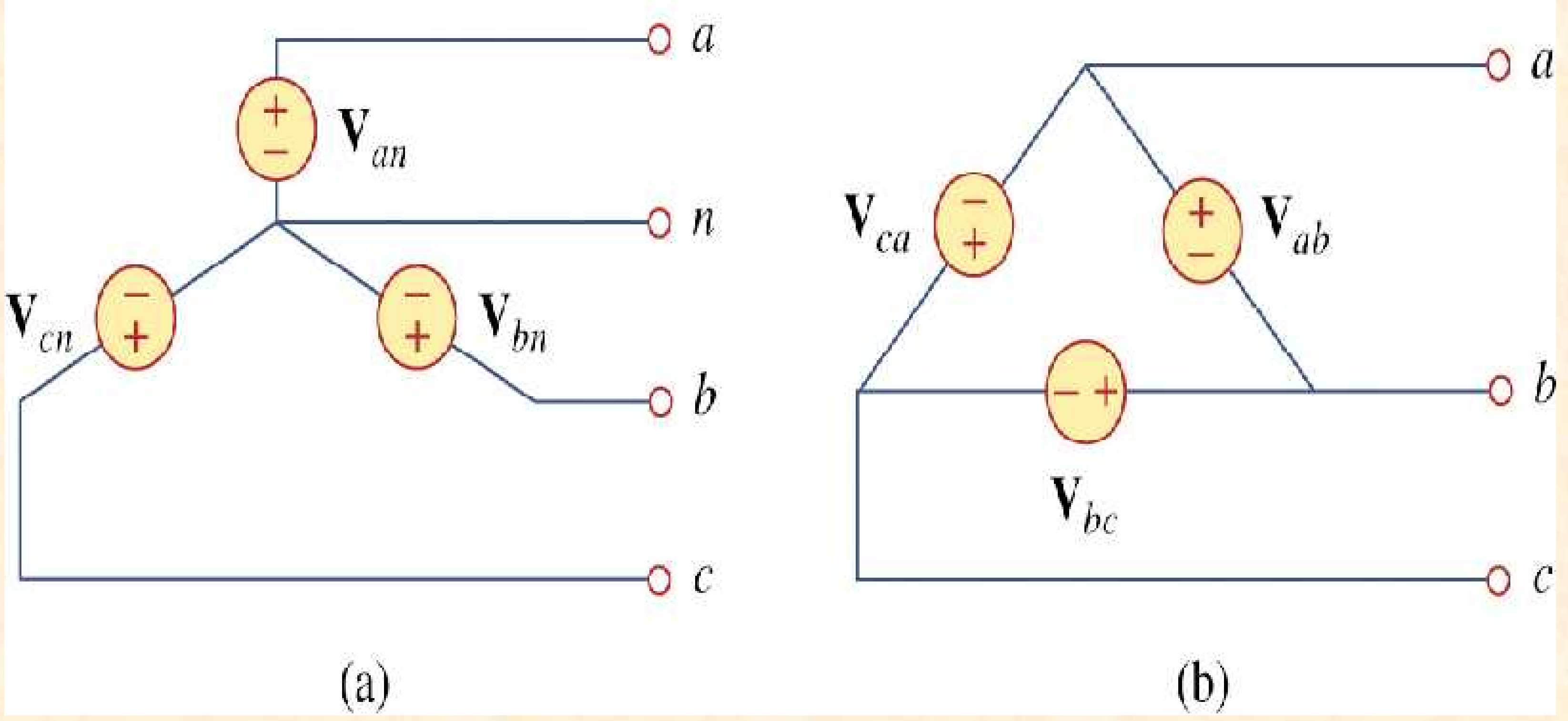
Three-Phase Voltages



Basic Three-Phase Circuit



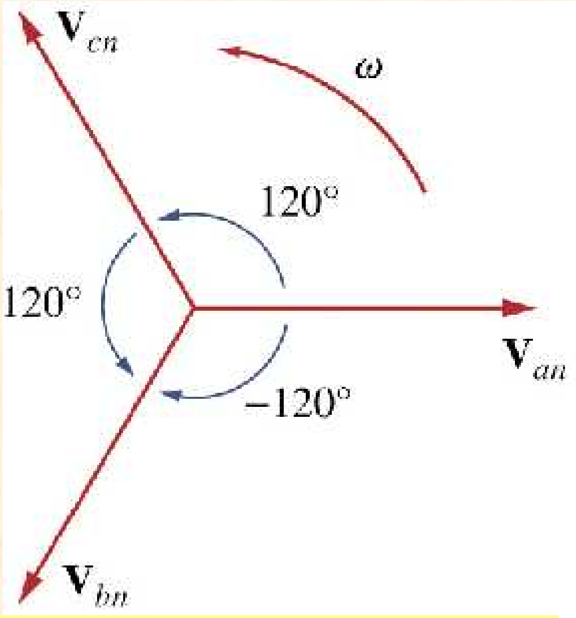
Three-Phase Voltages Sources



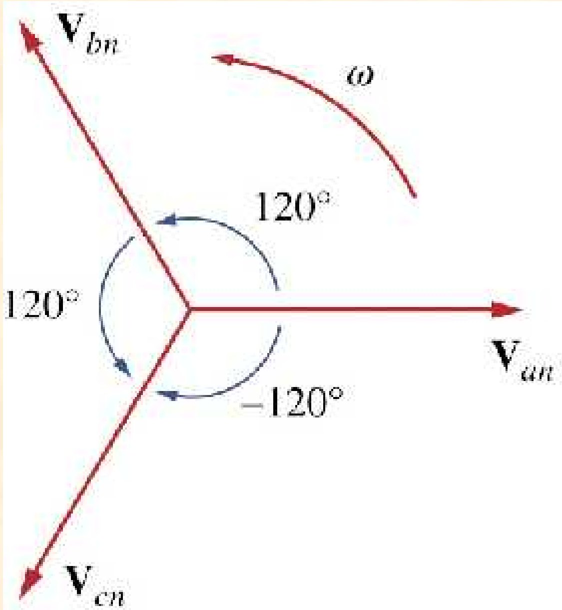
Y-connected Source **D-connected Source**

Balanced Three-Phase Voltages Sources

- **Balanced phase voltages** are equal in magnitude and are out of phase with one another by **120** degrees
- Phase voltages sum up to zero **($V_{an} + V_{bn} + V_{cn} = 0$)**
- There are **two possible combinations**:



abc or (+) sequence



acb or (J) sequence

Balanced Three-Phase Voltages

$$v_{an}(t) = V_M \cos(\mu t)$$
$$v_{bn}(t) = V_M \cos(\mu t - 120°)$$
$$v_{cn}(t) = V_M \cos(\mu t - 240°) = V_M \cos(\mu t + 120°)$$

$$V_{an} = V\angle 0°$$
$$V_{bn} = V\angle -120°$$
$$V_{cn} = V\angle +120°$$

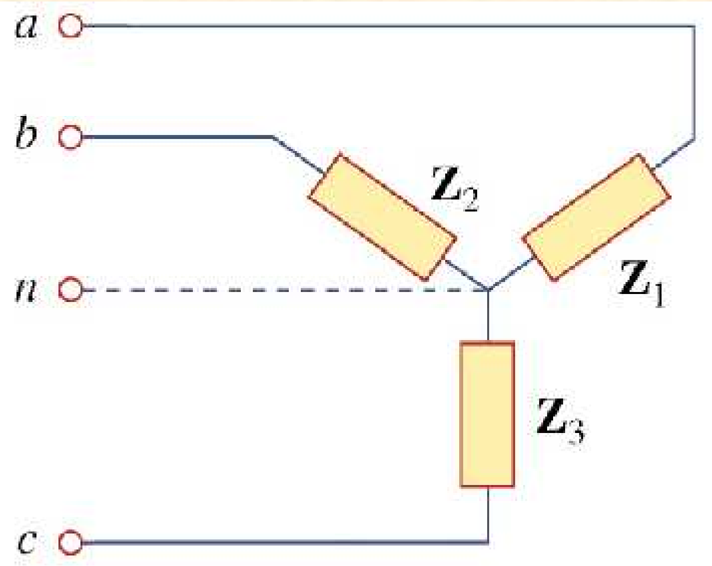
POSITIVE SEQUENCE

$$V_{an} = V\angle 0°$$
$$V_{bn} = V\angle +120°$$
$$V_{cn} = V\angle -120°$$

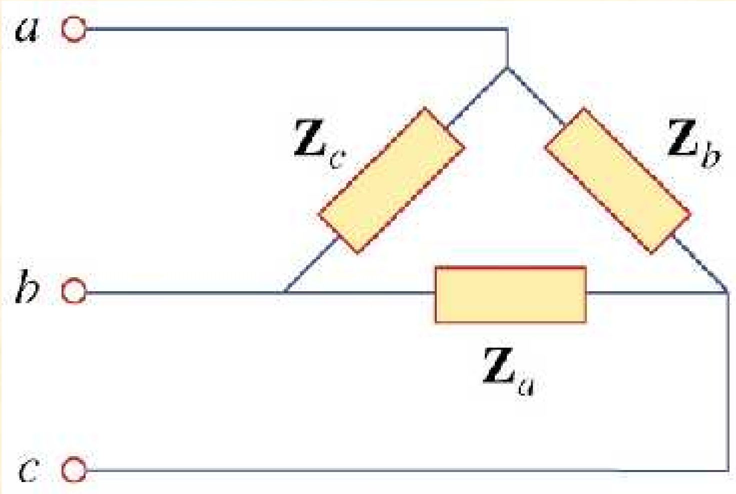
NEGATIVE SEQUENCE

Balanced Three-Phase Load Configurations

➢A **balanced three-phase load** is one in which the <u>phase impedances are equal</u> in **magnitude** and in **phase**



Y-connected Load



D-connected Load

Source-Load Connection

SOURCE	LOAD	CONNECTION
Wye	Wye	Y-Y
Wye	Delta	Y-a
Delta	Delta	a- a
Delta	Wye	a-Y

Three-Phase Quantities

QUANTITY	SYMBOL
Phase current	I_ϕ
Line current	I_L
Phase voltage	V_ϕ
Line voltage	V_L

Phase Voltages and Line Voltages & Currents

- Phase voltage, (V_ϕ) is measured between the neutral and any line: line to neutral voltage
- Line voltage, (V_L) is measured between any two of the three lines: line to line voltage
- Line current, (I_L) is the current in each line of the source or load
- Phase current, (I_ϕ) is the current in each phase of the source or load